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High-Resolution Mouse Brain Perfusion Imaging by Multi-pinhole Based X-ray Fluorescence Computed Tomography

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1 Introduction

We are developing an X-ray fluorescence computed tomography (XFCT) system [1,2] for preclinical studies as a new modality that provides biological function images similar to positron emission tomography and single photon emission computed tomography (SPECT). In this study, we constructed an ultra-high-resolution XFCT system using a multi-pinhole collimator with 15 pinholes of 0.1-mm diameter, and attempted to image the distribution of the non-radioactive iodine contrast agent accumulated in the mouse brain.

2 Experiment

XFCT system was constructed at the synchrotron radiation beamline NE7A of the High Energy Accelerator Research Organization PF-AR as shown in Fig. 1. A subject on a rotating stage was irradiated with high-brightness monochromatic X-rays with an energy of 33.2 keV just above K-absorption edge, which emitted a large amount of fluorescence from iodine. Fluorescence X-rays were detected by a two-dimensional detector placed at 90 degrees to the incident X-rays, and projected images of fluorescent X-rays were obtained. The detector had pixels of 0.172 mm × 0.172 mm arranged in 487 × 195, and the detection area was 83.8 mm wide × 33.5 mm long. Fluorescent X-rays passing through 15 (5 horizontal × 3 vertical) pinholes with 0.1 mm were projected onto the detection area without overlapping. Magnification is approximately 1x. Projected images from 180-derection/360-degree rotation were reconstructed by 3D-OSEM method for multi-pinhole XFCT. To evaluate spatial resolution, a Derenzo phantom with multiple holes of different diameters (0.35 mm to 0.7 mm) filled with 20 mg/ml iodine(I) solution was imaged for 1 minute per projection. In addition, ^{127}I-iofetamine (1.14 mg of iodine) was administrated intravenously to ddY mouse (male, 25 g body weight), and the brain was removed 5 minutes postinjection. The formalin-fixed brain was placed in a 10-mm diameter cylindrical container filled with water and imaged for 3 minutes per projection.

3 Results and Discussion

The reconstructed image of the Derenzo phantom clearly depicted the smallest diameter of 0.35 mm, showing a spatial resolution better than 0.35 mm (Fig. 2(a)). In addition, in imaging of the mouse brain, perfusion images of multiple slices were obtained, and the distribution of iodine agent was visualized with ultra-high resolution (Fig. 2(b)). This study demonstrated the feasibility of ultra-high-resolution functional imaging of the mouse brain by XFCT.

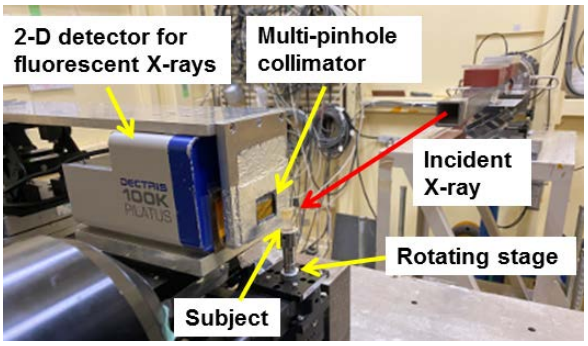
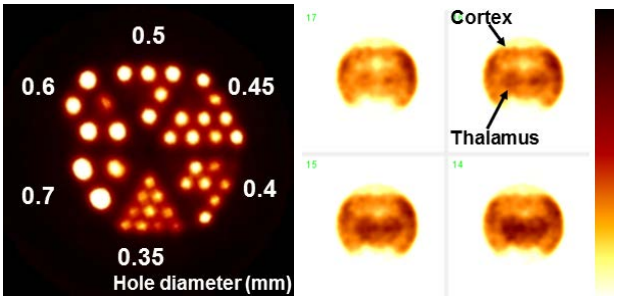


Fig. 1: Ultra-high-resolution multi-pinhole XFCT system.



(a) (b)

Fig. 2: (a) The reconstructed image of Derenzo phantom. Excellent spatial resolution of 0.35 mm or less. (b) Mouse brain perfusion multi-slice images.

Acknowledgement

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References

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